Simulation of rayleigh fading signal based on jake's model revisited

□ Jake's model revisited (2)를 이용하여 구현

$$T(t) = \sqrt{\frac{2}{N_0}} \sum_{n=1}^{N_0} [\cos(\beta_n) + I\sin(\beta_n)]\cos(\omega_n t + \theta_n)$$

- $I_R(t) = \sqrt{\frac{2}{N_0}} \sum_{n=1}^{N_0} \cos\beta_n \cos(w_n t + \theta_n)$

- $Q_R(t) = \sqrt{\frac{2}{N_0}} \sum_{n=1}^{N_0} I\sin\beta_n \cos(w_n t + \theta_n)$

○ condition : generation of two sets of Rayleigh fading signal
(fc = 1GHz and V = 50Km/h, fc = 1GHz and V = 100Km/h)

- $N_0 = 12,\ N = 48\ (N_0 = \frac{N}{4})$

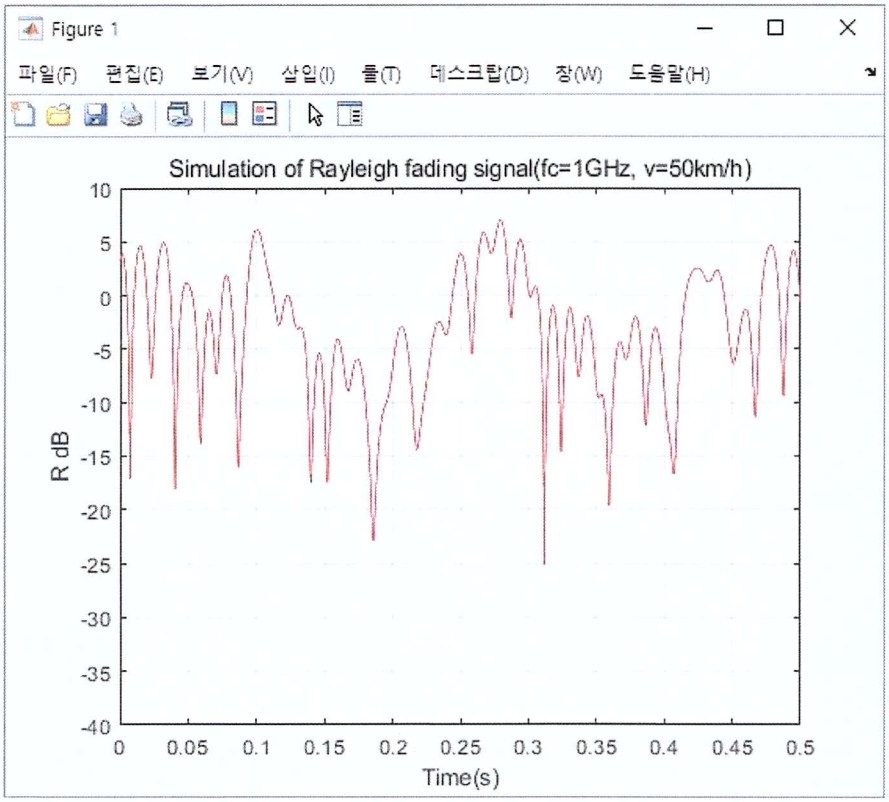
- $w_n = w_m \cos\left(\frac{2\pi n}{N}\right)$

- $\beta_n = \frac{n\pi}{N_0} = \frac{n\pi}{12}$

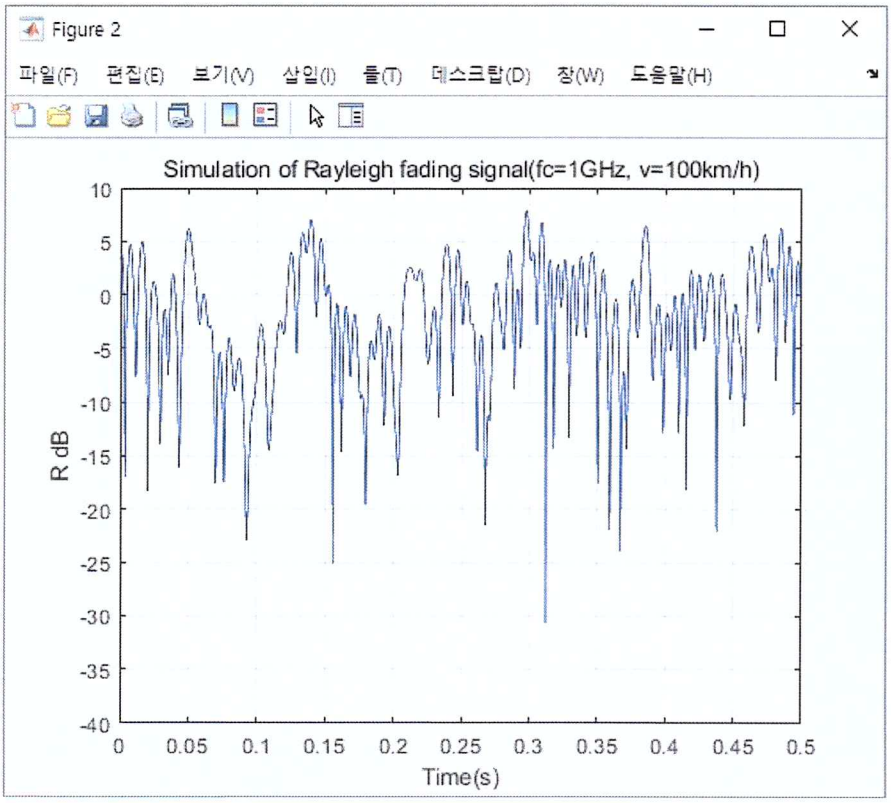
- $w_m = \frac{2\pi v}{\lambda} = \frac{2\pi \frac{(50 \times 10^{3(m)})}{3600(\sec)}}{0.15(m)}$ $(\lambda = \frac{c}{f} = \frac{3 \times 10^8}{1 \times 10^9} = 0.3(m))$,
$(v = 50km/h)$

☐ Rayleigh fading signal

○ Mobile speed : 50km/h



○ Mobile speed : 100km/h



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□ Matlab code

```
clear
close all
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%      Rayleigh Fading with Jake's model revisited       %
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
c=3e8; fc=1e9;         % Speed of light, Carrier Frequency
N0=12; N=4*N0;         % Number of path
v1=(50*1e3)/(3600);  % v1 = 50km/h
v2=(100*1e3)/(3600); % v2 = 100km/h
lamda=c/fc;
omega_m1=2*pi*v1/lamda;
omega_m2=2*pi*v2/lamda;
theta_n=rand(1,N0)*2*pi;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

t=0:1/10000:2;
Ir1=zeros(1,length(t));
Ir2=zeros(1,length(t));
Qr1=zeros(1,length(t));
Qr2=zeros(1,length(t));
Irn=[];
Qrn=[];

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%% fc=1GHz, v=50km/h %%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

for i = 1:N0
    beta = i*pi/(N0);
    omega_n=omega_m1*cos(2*pi*i/N);
    Irn=cos(beta)*cos(omega_n*t+theta_n(i));
    Qrn=j*sin(beta)*cos(omega_n*t+theta_n(i));
    Ir1=Ir1+Irn;
    Qr1=Qr1+Qrn;
end

Ir1=sqrt(2/N0)*Ir1;
Qr1=sqrt(2/N0)*Qr1;
Tt_v1=Ir1+Qr1;
```

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```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%% fc=1GHz, v=100km/h %%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
for i = 1:N0
    beta = i*pi/(N0);
    omega_n=omega_m2*cos(2*pi*i/N);
    Irn=cos(beta)*cos(omega_n*t+theta_n(i));
    Qrn=j*sin(beta)*cos(omega_n*t+theta_n(i));
    Ir2=Ir2+Irn;
    Qr2=Qr2+Qrn;
end

Ir2=sqrt(2/N0)*Ir2;
Qr2=sqrt(2/N0)*Qr2;
Tt_v2=Ir2+Qr2;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%% Received signal dB %%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

plot(t,20*log10(abs(Tt_v1)),'r');
title('Simulation of Rayleigh fading signal(fc=1GHz, v=50km/h)');
axis([0 0.5 -40 10]); grid;
xlabel('Time(s)');
ylabel('R dB');

figure
plot(t,20*log10(abs(Tt_v2)),'b');
title('Simulation of Rayleigh fading signal(fc=1GHz, v=100km/h)');
axis([0 0.5 -40 10]); grid;
xlabel('Time(s)');
ylabel('R dB');
```

Wireless communication

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<code>

used matlab.

```
function [h,tf]=jakes_model_revisited(fd,Ts,Ns,t0,E0,phi_N)

if nargin<6, phi_N=0; end
if nargin<5, E0=1;    end
if nargin<4, t0=0;    end
if nargin<3, error('need more input least arguments');end

N0=8;
N=4*N0+2;
wd=2*pi*fd;
t = t0+[0:Ns-1]*Ts;
tf = t(end)+Ts;

coswt = [sqrt(2)*cos(wd*t); 2*cos(wd*cos(2*pi/N*[1:N0]')*t)];
h = E0/sqrt(2*N0+1)*exp(1j*[phi_N pi/(N0+1)*[1:N0]])*coswt;
end
```

fd : doppler freq

phi_N : inital phase of the maximum dopper freq sinusoid

Ts : sampling period

N_S : number of samples

t0 : initial time

E0 : channel power

N0 : As suggested by Jakes (=8)

N : accurate approximation

wd : Maximum doppler freq

t : time vector

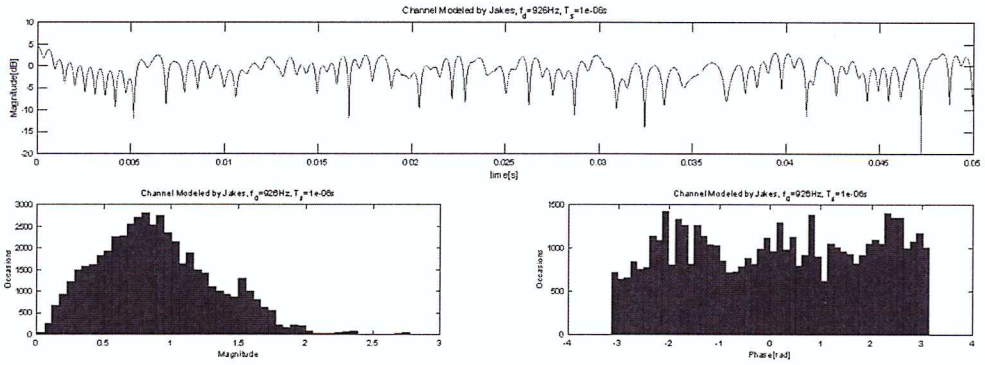
tf : final time

coswt : $w_n = w_d \cos\theta_n = 2\pi f_m \cos(2\pi n/N)$, $n = 1, 2, \cdots N_0$

h : fading vector : $h_I(t) = 2\sum_{n=1}^{N_0} (\cos\phi_n \cos w_n t) + \sqrt{2}\cos\phi_N \cos w_d t$

$h_Q(t) = 2\sum_{n=1}^{N_0} (\sin\phi_n \sin w_n t) + \sqrt{2}\sin\phi_N \cos w_d t$

<result>



〈Reference code〉

https://kr.mathworks.com/matlabcentral/fileexchange/9158-rayleigh-fading-channel-signal-generator-using-the-dent-model-a-modification-to-the-jakes-model

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Rayleigh Fading Channel Signal Generator Using the Dent Model (a modification to the Jakes Model)

version 1.0.0.0 (1.97 KB) by Avetis Ioannisyan

Use this function to create Rayleigh fading channels

Overview Functions Reviews (13) Discussions (7)

Dent Rayleigh model is similar to Jakes but uses Hadamard function in MATLAB to make the oscillators (somewhat) independent and thus provide results that are a little more realistic than the Jakes model.

For more details, please read IEEE paper by Wu Z. from 2004 (Electronics Letters, Volume: 40, Issue: 15) that covers the statistical performance of several models, including the Dent. In this paper Wu proposes his own model which is even better than the Dent.

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